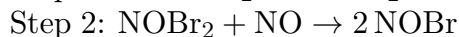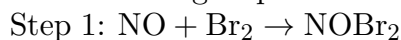This print-out should have 20 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001   10.0 points

What would you propose as the rate law for the reaction of bromine with nitric oxide if the second step of a proposed mechanism is the rate determining step?
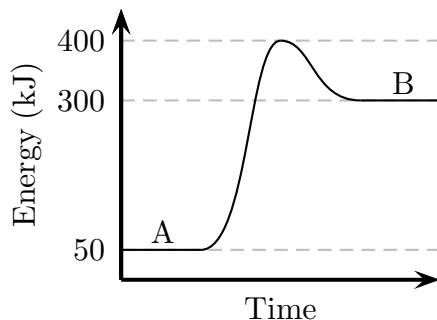   Step 1: $NO + Br_2 \rightarrow NOBr_2$
   Step 2: $NOBr_2 + NO \rightarrow 2\,NOBr$

1. $k\,[NO]^2\,[Br_2]\,[NOBr_2]^{-1}$

2. $k\,[NO]\,[Br_2]\,[NOBr_2]^{-1}$

3. $k\,[NO]^2$

4. $k\,[NO]\,[Br_2]\,[NOBr_2]$

5. $k\,[NO]^2\,[Br_2]$ **correct**

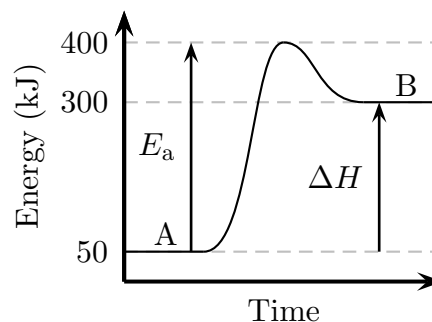**Explanation:**

002   10.0 points

   The graph describes the energy profile of a reaction.

What are the values for ΔH and E_a, respectively, for the reaction in the direction written?

1. -250 kJ, -100 kJ

2. -250 kJ, 100 kJ

3. 250 kJ, 350 kJ **correct**

4. -250 kJ, 350 kJ

5. 250 kJ, 100 kJ

Explanation:

$$\Delta H = 300 \text{ kJ} - 50 \text{ kJ} = 250 \text{ kJ}$$

$$E_a = 400 \text{ kJ} - 50 \text{ kJ} = 350 \text{ kJ}$$

003   10.0 points

The graph is a plot of ln A $vs\,t$ for the reaction

$$A \rightarrow B$$
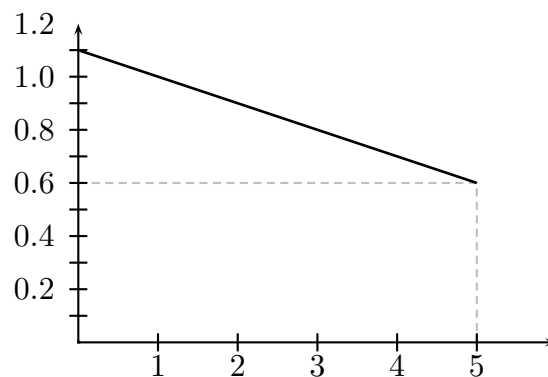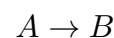
rate $= k\,[A]$ is the rate law for this reaction. What was the initial concentration of $[A]$?

1. 1.8 M

2. 3.0 M **correct**

3. 5 M

4. 0.6 M

5. 1.1 M

Explanation:

004   10.0 points

Which of the following statements regarding collision and transition state theory are true?

I) Reactants must collide to form products.
II) Activation energy is always positive.
III) Reactant molecules must absorb energy to form the transition state.
IV) Reactant collisions must be oriented properly to form products.

1. II and III only
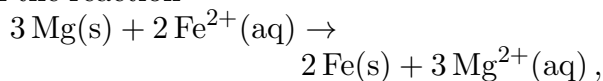
2. I, III, and IV only

3. I, II, III, and IV **correct**

4. I and IV only

5. II, III, and IV only

Explanation:

005　10.0 points

In the reaction
$$3\,\mathrm{Mg(s)} + 2\,\mathrm{Fe^{2+}(aq)} \rightarrow$$
$$2\,\mathrm{Fe(s)} + 3\,\mathrm{Mg^{2+}(aq)},$$
$\dfrac{\Delta[\mathrm{Fe}]}{\Delta t} = 2.4 \times 10^{-4}$ M/s. What is $\dfrac{\Delta[\mathrm{Mg}]}{\Delta t}$?

1. -3.6×10^{-4} M/s **correct**

2. -1.6×10^{-4} M/s

3. $+3.6 \times 10^{-4}$ M/s

4. $+1.6 \times 10^{-4}$ M/s

5. $+1.2 \times 10^{-4}$ M/s

Explanation:

006　10.0 points

A reaction has a rate constant of $k = 5.5 \times 10^{-4}$ $\mathrm{M^2 s^{-1}}$. What is the reaction order?

1. -2

2. 0

3. 1

4. 2

5. -1 **correct**

Explanation:

007　10.0 points

What is the rate law for the reaction

$$A + B + C \rightarrow D$$

if the following data were collected?

Exp	$[A]_0$	$[B]_0$	$[C]_0$	Initial Rate
1	0.4	1.2	0.7	2.32×10^{-3}
2	1.3	1.2	0.9	7.54×10^{-3}
3	0.4	4.1	0.8	9.25×10^{-2}
4	1.3	1.2	0.2	7.54×10^{-3}

1. rate $= 3.36 \times 10^{-3} [A]^1 [B]^3 [C]^0$ **correct**

2. rate $= 1.79 \times 10^{-3} [A]^0 [B]^2 [C]^1$

3. rate $= 1.49 \times 10^{-3} [A]^0 [B]^3 [C]^1$

4. rate $= 4.48 \times 10^{-3} [A]^1 [B]^2 [C]^1$

5. rate $= 5.37 \times 10^{-3} [A]^1 [B]^3 [C]^0$

Explanation:

008　10.0 points

The decomposition of hydrogen peroxide to form water is a first order process. If it takes 20 minutes for the initial concentration to fall from 1.6 M to 0.8 M, how much time has passed when only 0.05 M of the initial 1.6 M remains?

1. 100 minutes **correct**

2. 120 minutes

3. 80 minutes

4. 160 minutes

5. 40 minutes

Explanation:

009　10.0 points

At 0°C and 1 atmosphere of pressure, which of the following gases would have the lowest average molecular speed?

1. H_2

2. NH_3

3. N_2

4. CO_2 **correct**

5. Ar

Explanation:
Light molecules have higher velocities (or speeds) than heavier molecules at a given temperature, so you need to consider the molecular weights of these molecules:

$$MW_{N_2} = 28 \text{ g/mol}$$
$$MW_{NH_3} = 17 \text{ g/mol}$$
$$MW_{H_2} = 2 \text{ g/mol}$$
$$MW_{Ar} = 40 \text{ g/mol}$$
$$MW_{CO_2} = 44 \text{ g/mol}$$

CO_2 is the heaviest molecule, so its average molecular speed will be the lowest.

010　10.0 points
What is the molecular weight of a (hypothetical) gas that diffuses 1.414 times faster than nitrogen (N_2)?

1. 23.5 g/mol

2. 32.6 g/mol

3. 14.0 g/mol **correct**

4. 46.6 g/mol

5. 4.85 g/mol

Explanation:

011　10.0 points
Given the gases Cl_2, Kr, CO_2, Ne, put them in order of their INCREASING rate of effusion.

1. $CO_2 < Ne < Kr < Cl_2$

2. $Kr < Cl_2 < CO_2 < Ne$ **correct**

3. $Cl_2 < Kr < Ne < CO_2$

4. $Ne < CO_2 < Cl_2 < Kr$

Explanation:
Effusion is when gas molecules escape through the tiny holes in their container. Lighter, faster molecules effuse more quickly than heavy, slow ones.

$$Kr_{(MW=84 \text{ g/mol})} < Cl_{2(MW=71 \text{ g/mol})}$$
$$< CO_{2(MW=44 \text{ g/mol})}$$
$$< Ne_{(MW=20 \text{ g/mol})}$$

012　10.0 points
In an improved version of the gas law, P is replaced by $\left(P + \dfrac{n^2 a}{V^2} \right)$. In this expression, the second term, $\dfrac{n^2 a}{V^2}$, accounts for

1. the forces of repulsion between molecules.

2. the excluded volume of the molecules.

3. the forces of attraction between molecules. **correct**

4. the size of the molecules.

5. the size of the container.

Explanation:
At high pressures, gas molecules are closer together than they would be at lower pressures. The attractive forces between gas molecules then become important.

When more molecules are present (greater n) and when the molecules are close together (smaller V^2 in the denominator), the correction term becomes larger.

In this correction term, large values of a indicate strong attractive forces, and the correction term as a whole is added to compensate for attractive forces between gas molecules.

013　10.0 points

Under which of the following conditions is a real gas most likely to deviate from ideal behavior?

1. Tuesdays and Thursdays

2. zero pressure

3. if it is a noble gas

4. high volume

5. low pressure

6. low temperature **correct**

7. new moon

8. low density

Explanation:
Deviations from ideality occur due to molecular attractions or repulsions. More attractions or repulsions can occur when the molecules are closer together. Low pressure, high volume, and low density all correspond to molecules being far apart. Low temperature often corresponds to molecules being close together. It also corresponds to low kinetic energy which allows molecules to 'stick together' easier.

014　10.0 points

If 250 mL of a gas at STP weighs 2 g, what is the molar mass of the gas?

1. $8.00 \text{ g} \cdot \text{mol}^{-1}$

2. $44.8 \text{ g} \cdot \text{mol}^{-1}$

3. $56.0 \text{ g} \cdot \text{mol}^{-1}$

4. $28.0 \text{ g} \cdot \text{mol}^{-1}$

5. $179 \text{ g} \cdot \text{mol}^{-1}$ **correct**

Explanation:
$$V = 250 \text{ mL} \qquad\qquad P = 1 \text{ atm}$$
$$T = 0°\text{C} = 273.15 \text{ K} \qquad\qquad m = 2 \text{ g}$$
The density of the sample is

$$\rho = \frac{m}{V} = \frac{2 \text{ g}}{0.25 \text{ L}} = 8 \text{ g/L}$$

The ideal gas law is

$$P V = n R T$$
$$\frac{n}{V} = \frac{P}{R T}$$

with unit of measure mol/L on each side. Multiplying each by molar mass (MM) gives

$$\frac{n}{V} \cdot \text{MM} = \frac{P}{R T} \cdot \text{MM} = \rho,$$

with units of g/L.

$$
\begin{aligned}
\text{MM} &= \frac{\rho R T}{P} \\
&= \frac{(8 \text{ g/L})(0.08206 \text{ L} \cdot \text{atm/mol/K})}{1 \text{ atm}} \\
&\quad \times (273.15 \text{ K}) \\
&= 179.318 \text{ g/mol}
\end{aligned}
$$

015　10.0 points

At constant temperature, the rate of effusion of H_2 is

1. None of these

2. one-fourth that of oxygen gas.

3. twice that of helium gas.

4. four times that of oxygen gas. **correct**

5. one-half that of helium gas.

Explanation:

$$\frac{\text{Rate of effusion of } O_2}{\text{Rate of effusion of } H_2} = \frac{\sqrt{\text{MW}_{H_2}}}{\sqrt{\text{MW}_{O_2}}}$$

$$\frac{\text{Eff}_{O_2}}{\text{Eff}_{H_2}} = \sqrt{\frac{2}{32}} = 0.25 = \frac{1}{4}$$

$$\text{Eff}_{O_2} = \frac{1}{4} \text{ Eff}_{H_2}$$

016   10.0 points
Which of the following molecules would have the smallest a and b term, respectively, in the van der Waals' equation: O_3, CHF_3, SF_5Cl, $SiHCl_3$, Xe.

1. Xe and SF_5Cl, respectively

2. Xe and O_3, respectively **correct**

3. CHF_3 and CHF_3, respectively

4. Xe and Xe, respectively

5. $SiHCl_3$ and O_3, respectively

Explanation:
Xenon is the only non-polar species and thus would have the smallest a term. Ozone is the smallest in terms of molecular weight and would thus have the smallest b term.

017   10.0 points
If a 10 L gaseous system at 400 K and 4 atm is heated to 800 K and allowed to expand to 20 L, what will the new pressure of the system be?

1. 2 atm

2. 16 atm

3. 4 atm **correct**

4. 1 atm

5. 8 atm

Explanation:
Doubling the temperature from 400 K to 800 K will double the pressure and doubling the volume from 10 L to 20 L will halve the pressure, resulting in no net change in pressure.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$P2 = \frac{P_1 V_1 T_2}{V_2 T_1} = \frac{4 \cdot 10 \cdot 800}{20 \cdot 400} = 4 \text{ atm}$$

018   10.0 points

A sample of gas occupies 10.5 L at 600 torr and 50°C. What volume will it occupy at STP?

1. 7.01 L **correct**

2. 9.81 L

3. 11.2 L

4. 15.7 L

Explanation:
$P_1 = 600$ torr $\qquad\qquad P_2 = 760$ torr
$V_1 = 10.5$ L $\qquad\qquad T_2 = 273.15$ K
$T_1 = 50°C + 273.15 = 323.15$ K

We can use the combined gas law and solve for V_2:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$V_2 = \frac{P_1 V_1 T_2}{T_1 P_2}$$

$$= \frac{(600 \text{ torr}) (10.5 \text{ L}) (273.15 \text{ K})}{(323.15 \text{ K}) (760 \text{ torr})}$$

$$= 7.00687 \text{ L}$$

019   10.0 points
If the temperature of an ideal gas is raised from 100°C to 200°C, while the pressure remains constant, the volume

1. increases by a factor of 100.

2. None of these **correct**

3. remains the same.

4. doubles.

5. goes to $\frac{1}{2}$ of the original volume.

Explanation:
$T_1 = 100°$ C $+ 273 = 373$ K
$T_2 = 200°$ C $+ 273 = 473$ K

Volume is directly proportional to temperature expressed on the Kelvin scale:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{V_2}{V_1} = \frac{T_2}{T_1}$$

The temperature changes by a factor of

$$\frac{T_2}{T_1} = \frac{473 \text{ K}}{373 \text{ K}} = 1.27 \,,$$

so the volume increases by the same factor 1.27. None of the specific answers gives this factor.

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020   10.0 points

The molar volume of a gas at STP is

1. 22.4 liters. **correct**

2. 12.4 gallons.

3. 6.02×10^{23} liters.

4. 12.4 liters.

Explanation:
   Avogadro's Law states that at the same temperature and pressure, equal volumes of all gases contain the same number of molecules. The standard molar volume of an ideal gas is taken to be 22.414 liters per mol at STP.